Gartner Lee Associates Limited

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Consulting Engineering Geologists and Hydrogeologists

Toronto-Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-297-4600

CONTRACT REPORT NO. OSQ80-00103

# CONTINUOUS CORE SAMPLING OF THE NORDIC URANIUM TAILINGS AND NATIVE SOIL MATERIALS

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Toronto-Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-297-4600

February 27th, 1981

Energy, Mines and Resources Canada,
CANMET,
Elliot Lake Laboratory,
P.O. Box 100,
Elliot Lake, Ontario.
P5A 2J6

Attention: Mr. T. P. Lim

Dear Sirs:

Re: Continuous Core Sampling of the
Nordic Uranium Tailings and Native Soil Materials

We have completed the above noted project and are pleased to submit a summary in the attached report.

This project was carried out by Mr. R. J. Blackport under our supervision. Mr. Blackport has forwarded a description of the samples and locations under seperate cover. This report deals with the techniques used, difficulties encountered and degrees of success achieved for the sampling program.

Although a number of existing samplers were used during this program, none were found to be very effective within the saturated tailings. Clearly, a new sampling technique must be developed if a better understanding of the physical and chemical processes in tailings is to be achieved.

continued -

We trust this report will be of assistance in your overall work program and thank you for letting us be of service on this most interesting project.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED

Grant Anderson

E. G. Anderson, P.Eng.,
Consulting Hydrogeologist

EGA/sv

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# 1.0 INTRODUCTION:

## 1.1 BACKGROUND:

The Nordic tailings area immediately east of Elliot Lake, Ontario, is currently being studied to determine hydrogeological and geochemical processes that affect the chemical evolution and movement of pore water in inactive uranium tailings. In conjunction with this, determination of a radionuclide mass balance is being carried out by comparing the initial mass of radionuclides present when the tailings were deposited and the mass now present both within the solid tailings and pore water within the tailings. This will facilitate estimating the mass which has been removed from the tailings. This work is being carried out under the supervision of the Canadian Mining and Energy Technology (CANMET) division of the Department of Energy Mines and Resources through various contracts funded by the Federal Department of Supply and Services (DSS).

The Nordic tailings area covers about 85 hectares with an average thickness of 10 m and contains 15 million tonnes of tailings with 4-7% pyrite (Blair et al, 1980). The tailings are produced by an acid-leach process and are neutralized to pH levels of 8 to 10 before being discharged from the mill. Piezometers have been installed at numerous locations in the two tailings areas, the Nordic Main and the Nordic West Arm (Figure 1), to investigate pore water evolution in the inactive tailings.

Oxidation of the pyrite is causing the original basic pore water to be gradually replaced by acidic pore water. This change in pore water pH results in mobilization of radionuclides and heavy metals in the tailings. Previous investigators (see references) have shown that, where tailings are coarse grained with downward ground water flow, the entire thickness of the tailings has become acidic. In areas where tailings are fine grained and flow is upwards, much of the tailings pore water is still basic. (Blackport and Cherry, 1980).

There is a significant variation in the mass of radionuclide movement throughout the tailings area as a result of this variation in ground water flow and pore water chemistry. In order to carry out a radionuclide mass balance and gain a better understanding of the processes

that affect pore water evolution it will be important to determine the present chemical composition of the solid tailings especially at points where the pore water chemistry is known. As a result it will be necessary to obtain soil samples that are relatively undistrubed and uncontaminated for more reliable and accurate chemical analyses.

## 1.2 Purpose and Scope:

A previous investigation (Cherry et al, 1980) dealt almost exclusively with the physical hydrogeology and the chemistry of the pore water within both the tailings and the underlying aquifer. In order to carry out a radionuclide mass balance within the tailings and gain a better understanding of the geochemical evolution of the tailings, soil samples must be obtained from the tailings, and the underl ing material for chemical analyses.

It is important to obtain soil samples which are relatively undistrubed and uncontaminated. Several factors must be taken into consideration when obtaining samples of this type so as not to introduce any form of contamination either by addition of foreign material or cross contamination between sampling depths. These factors will be discussed in Section 2.0.

These samples need to be taken near existing ground water monitors to compare the solid chemistry with the existing pore water chemistry at the same location. Sampling was carried out at all ground water monitoring sites in the Nordic Main tailings as it was determined in discussions with CANMET personnel that the Nordic Main tailings would be most suitable for carrying out a radionuclide mass balance. In the Nordic West Arm tailings soil sampling was carried out at a number of the ground water monitoring sites and are representative of a variety of ground water flow and pore water chemistry conditions at the site (Blackport and Cherry, 1980).

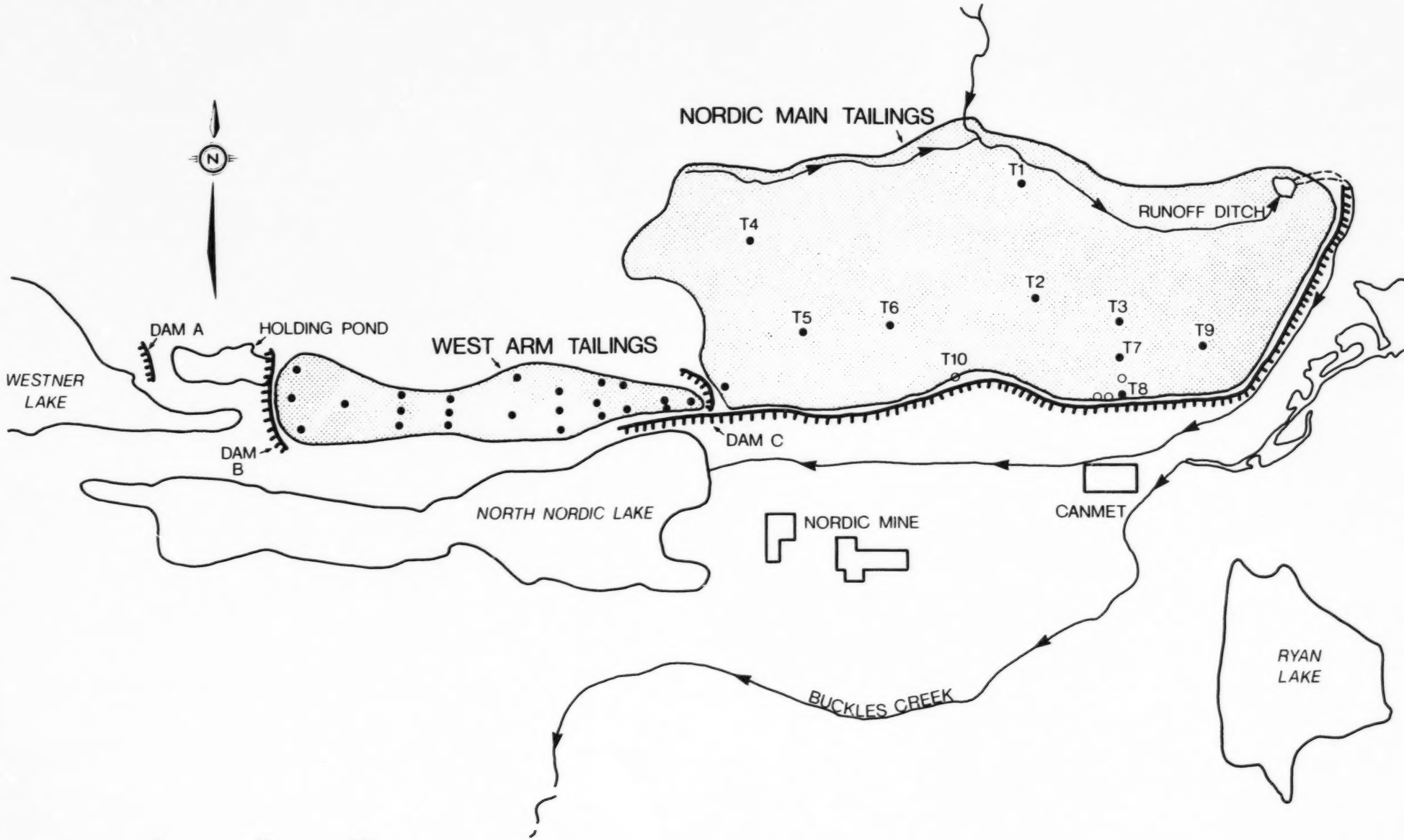



**Figure 1-** Location Map & Monitoring Sites (Cherry et al, 1980)

## 1.3 Site Setting and Tailings Deposition:

The Nordic West Arm and Nordic Main tailings impoundments are situated in a glaciated valley underlain by Lower Proterozoic arenaceous sedimentary rocks striking east - west and dipping to the north. The bedrock valley was infilled with Pleistocene glacial deposits (Figure 2). At the base of the glacial deposits is a thin layer of sandy, bouldery, glacial till. Above this is a glacio-fluvial sand and gravel up to 30 m thick at some locations. The sand is overlain by a discontinuous pebble gravel varying in thickness from 0.5 m to 3 m. These deposits are in turn overlain by a discontinuous layer of black peat up to 1 m thick formed in a spruce bog that existed in the area before the tailings were laid down.

Deposition of talings in the Nordic West Arm began in 1957 and ended in 1960. Tailings were deposited after construction of two dams at the west end of the tailings (Figure 1) and flow was altered to discharge through the east end. Tailings were deposited in the middle of the West Arm and the discharge point was moved progressively westward to Dam B. More storage volume was required and Dam C was raised in 1960 to create the Nordic Main site. The West Arm tailings area was left inactive at this time.

Tailings were dposited in the Nordic Main area from 1960 to 1968, beginning in the southwest corner and extending north and east. Broad low angle alluvial fans were formed in which the coarsest tailings settle out near the discharge pipe and the finer tailings further from the discharge pipe. As a result, the depositional environment at any location in the tailings depends on the proximity to the various locations of the discharge points and the volume of tailings discharged at each location. This variable nature of the tailings composition has a significant effect on the hydrogeology and geochemistry of the area.

## 1.4 Hydrogeology of The Nordic Tailings:

The hydrogeology and geochemistry of the Nordic tailings have been described in detail by Blair et al (1980), Blackport and Cherry (1980) and Cherry et al (1980), Figure 1 shows the location of monitoring sites at the Nordic Main and Nordic West Arm tailings areas. Figures 3

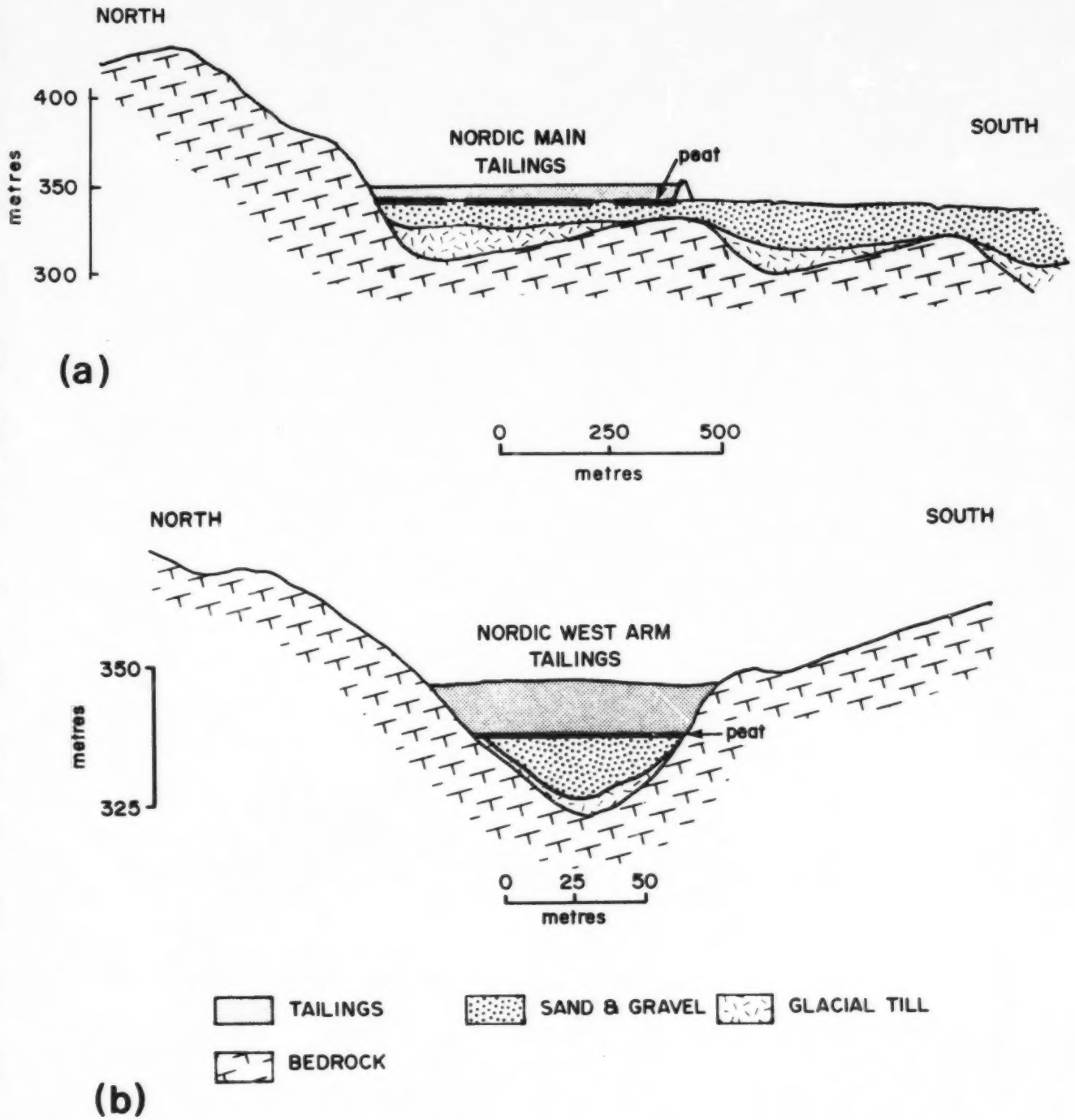



**Figure 2** - Represntative Geological Cross-Sections (Cherry et al, 1980)

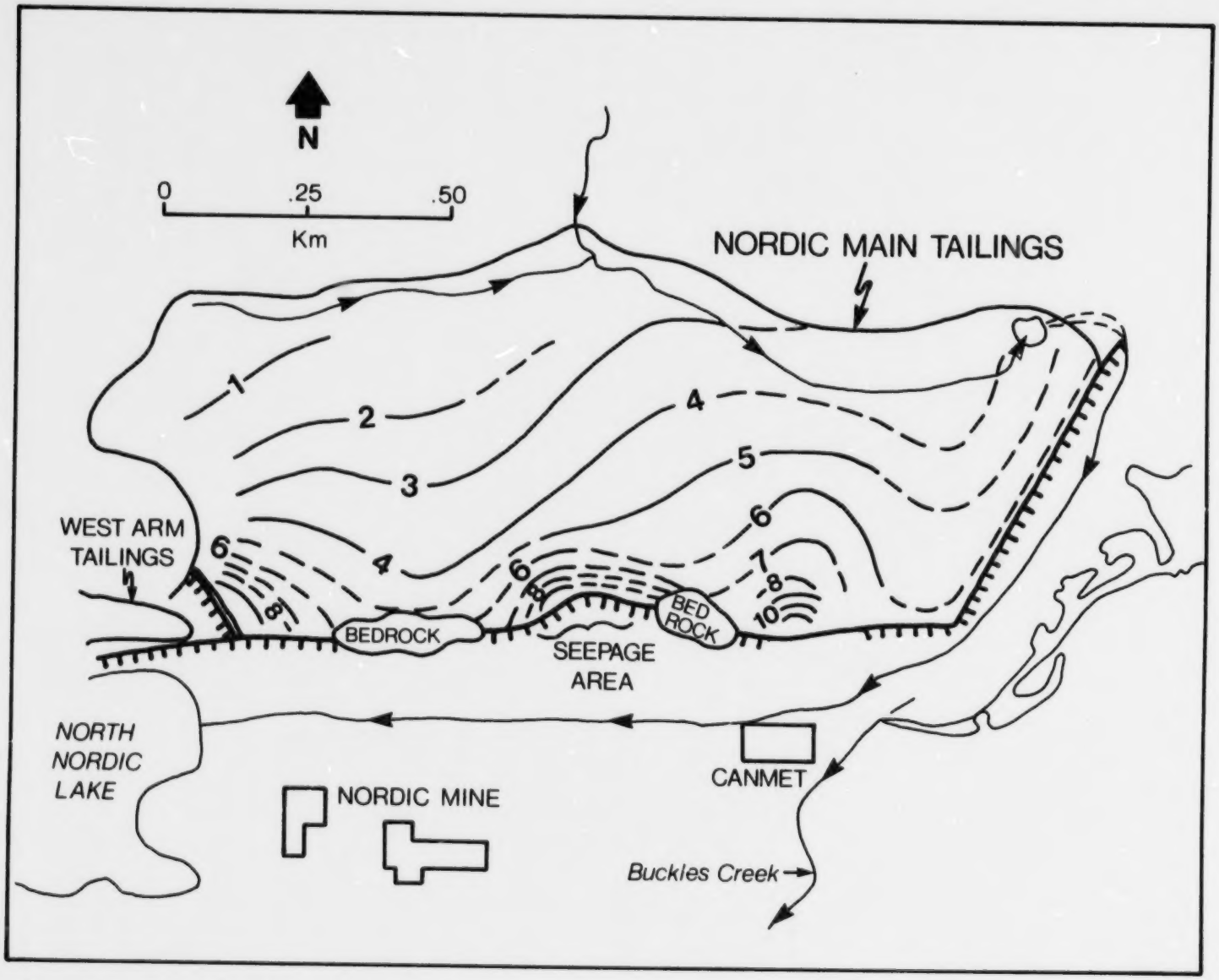



**Figure 3** - Depth to Water Table (metre) - Nordic Main Tailings (Cherry et al, 1980)

and 4 show the depth to water at the Nordic Main and Nordic West Arm tailings areas respectively.

Flow in the Nordic Main tailings is vertically downward and horizontally toward the Dam C tailings impoundment. Flow in the Nordic West Arm tailings is away from a central mound in the horizontal direction, vertically downward in the western and central portion of the tailings, and vertically upward in the eastern portion of the tailings.

The chemistry of the porewater is highly variable with the lowest pH and highest electrical conductance occurring in areas of one or a combination of the following: a) greater depth to water table; b) coarser tailings; or, c) greater ground water velocity. Significant variations in porewater chemistry occur very close together in some locations. Perhaps the solids chemical character, possibly influenced by grain size distribution, will determine to some extent the chemical composition of the porewater.

## 2.0 SAMPLING TECHNIQUES AND APPLICABILITY:

A number of factors must be considered when determining which sampling technique would be the most useful for obtaining soil samples at the Nordic site in order to minimize contamination and maximize recovery.

Firstly, there must be no introduction of foreign drilling materials (i.e. water, drilling mud etc.) as this introduces the possibility of changes in chemical composition of both the solid tailings and porewater within the tailings. This is important because of the analytical techniques used by CANMET. From discussions with CANMET personnel, samples are collected, placed in airtight containers and weighed wet. Samples are then dried and weighed in order to determine the sample moisture content. When this water is evaporated a residue is left behind on the solids. This residue is impossible to separate by direct measurement. If however, the porewater chemistry is known at the sample location then the chemical composition of the residue can be calculated and subtracted from the overall analysis. As can be seen, the introduction of foreign substances will result in errors in determination of the solid chemistry. However,

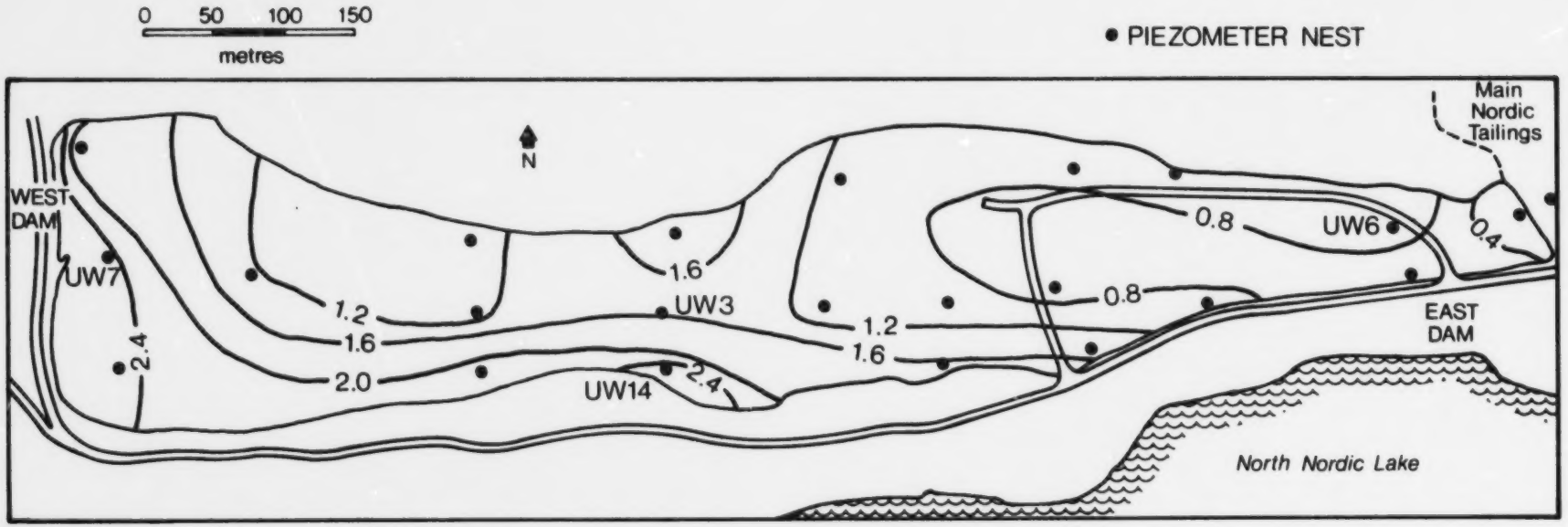



**Figure 4** - Depth to Water Table (metre) - Nordic West Arm
(Blackport & Cherry, 1980)

with respect to obtaining soil samples in the field, this may create problems as discussed in later sections when dealing with individual sampling techniques.

In addition as discussed in Section 1.2, there are variations in tailings grain size composition both areally and vertically. There is also a variation in the native material underlying the tailings. As a result, the following factors must be taken into consideration when determining the applicability of sampling techniques:

(1) depth to the water table;

(2) the cohesiveness of the tailings over small vertical distances;

(3) the cohesiveness of the tailings over large vertical distances;

(4) the presence and location of the underlying peat layer, and

(5) the variability in grain size (i.e. fine-grained sand to coarse gravel) of the underlying glacial material.

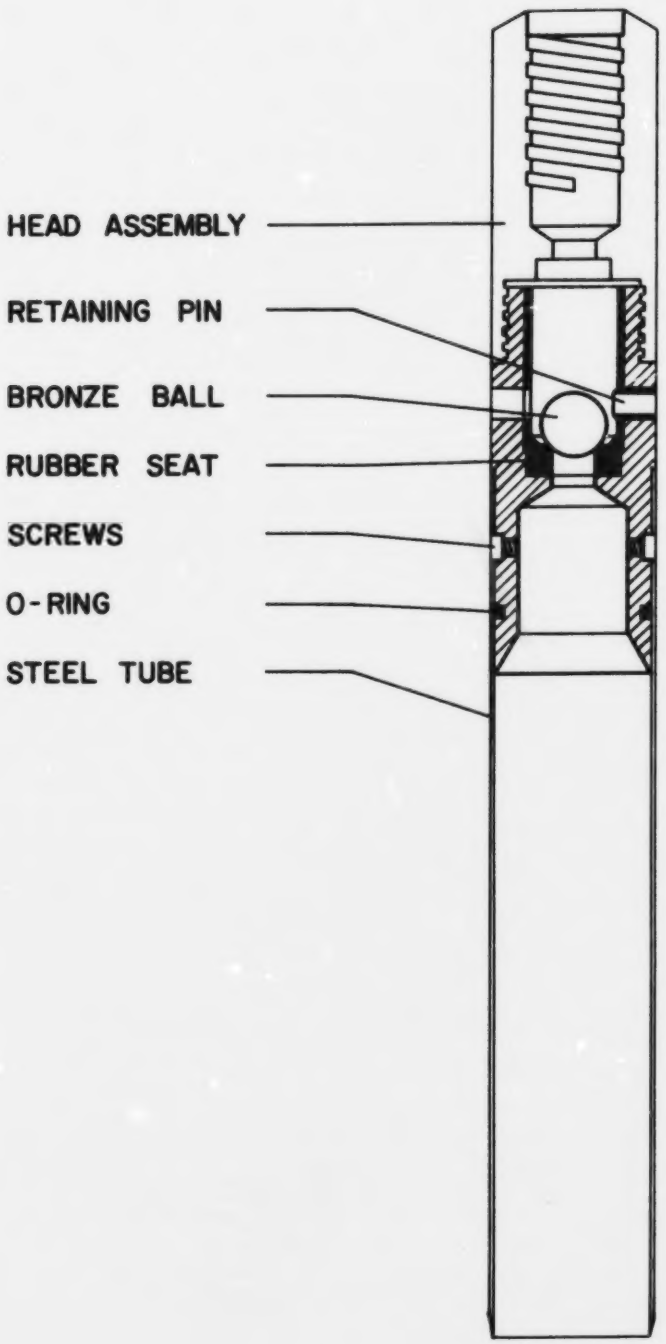
## 2.1 Classical Shelby Tube Sampler:

A Shelby Tube is a trade name for hard-drawn seamless steel tubing used as a thin-walled open-drive soil sampler. An open-drive removable sampler (Shelby Tube) is attached to a drilling head in preparation for sampling (Figure 5). Open-drive samplers are forced into the ground by pushing or jacking and then extracted. Samples are available in three general sizes (5.1,7.1 and 8.6 cm I.D.) and in lengths up to 76.2 cm .

Krynine and Judd (1957) concluded that samplers for taking relatively undisturbed cohesive soil samples should be thin-walled. A thin-walled sampler conventionally has a sampling tube with a wall thickness less than 2.5% of the diameter. The ratio of the volume of the soil displaced by the sampler to the total volume of the sample extracted ("area ratio") is about 10% meaning that the damage caused to the sample while sampling is relatively small.

Samples are often shorter than the column of earth from which it has been extracted. This shortening of the sample is caused by some compaction of the material, by the downward deflection of the soil layers near the walls of the sampler, and by the stretching of these soil layers. The ratio of the length of the sample to the length of the

**Figure 5**: Thin Wall Shelby Tube Sampler



soil column is the recovery ratio and varies depending on the grain size distribution and soil layering in the soil column.

During extraction of the sampler from the borehole there may be a loss of the sample, especially in soft cohesionless soil. This results from friction on the side wall being unable to overcome the suction forces at the bottom. This is quite significant in fine-grained tailings material. Once below the water table, hydrostatic pressures at the base of the borehole may result in material coming up the borehole annulus. Thus, the soil sample taken in a short Shelby Tube may be over compacted and not representative of the samping depth.

In areas where the sample will be retained by side-wall friction and excess hydrostatic pressurers are not present (i.e. above or at the water table). Shelby Tube samples have been shown to be an efficient way of obtaining relatively undisturbed and uncontaminated samples.

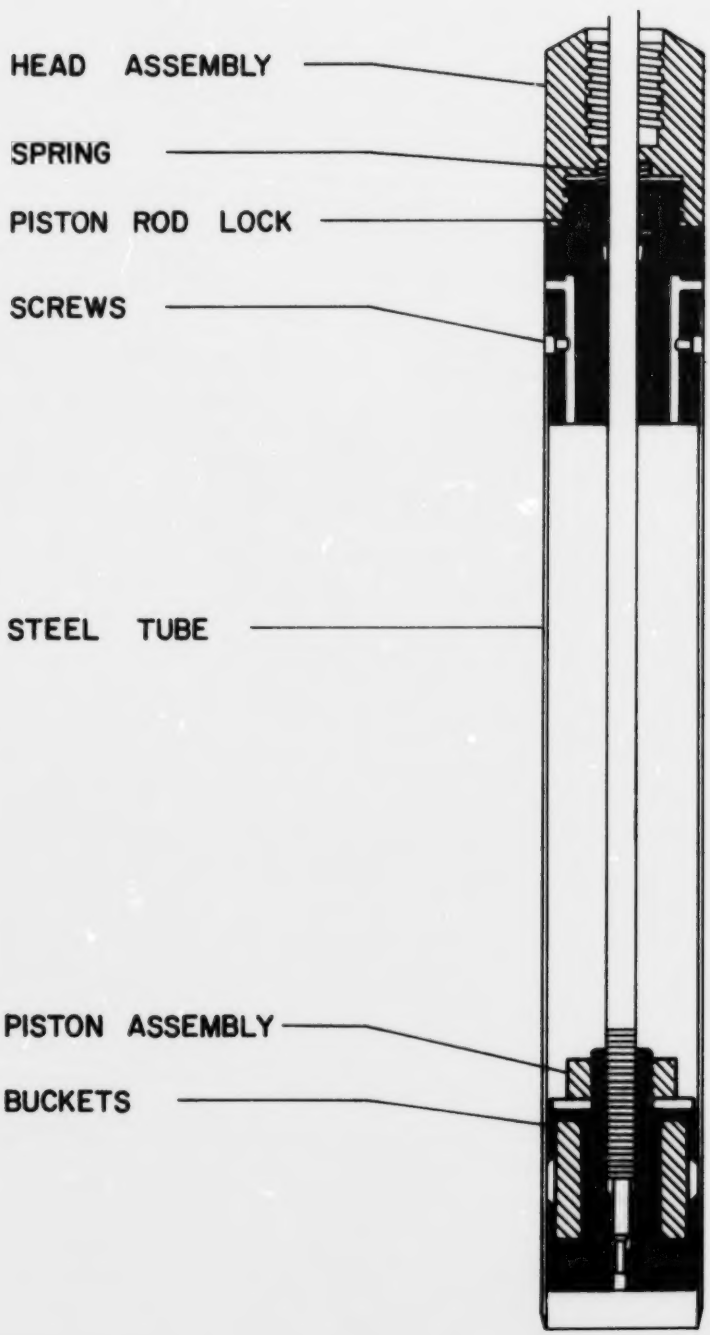
## 2.2 Piston Samples:

A piston sampler is a drive sampler in which the lower end may be closed by a piston operated from the ground surface by a piston rod. A sampler, which is usually a Shelby Tube has a closed bottom (Figure 6) and is forced or lowered into the ground until the proper depth is reached. In this way no disturbed material from within the borehole annulus enters the sampling tube before the desired sample is extracted.

There are three kinds of pistons, the stationary, the retractable, and free, of which the most common, the stationary, was used at the Nordic tailings.

With the stationary piston sampler, the piston rod is clamped to the drill rod in such a way that the piston is flush with the bottom of the Shelby Tube at the cutting edge (Figure 6). The piston is placed at the level where the sample is to be taken. (i.e. the bottom of the borehole). As the sample is taken, the piston remains at this level by releasing the clamp to the drill rod and clamping the piston rod to something stable. The clamp is released when the sampling tube is full and the sample withdrawan. A special cone clamp prevents the

**Figure 6:** Stationary Piston Sampler



downward movement of the samples during withdrawal.

The advantage of the piston sampler over the classical Shelby Tube is that it can be used below the water table regardless of a trace of disturbed soil at the bottom of the borehole. The piston sampler was designed for fine-grained soils. One of the major disadvantages is that it is a much slower and more cumbersome method of obtaining soil samples at any depth, compared to most other methods.

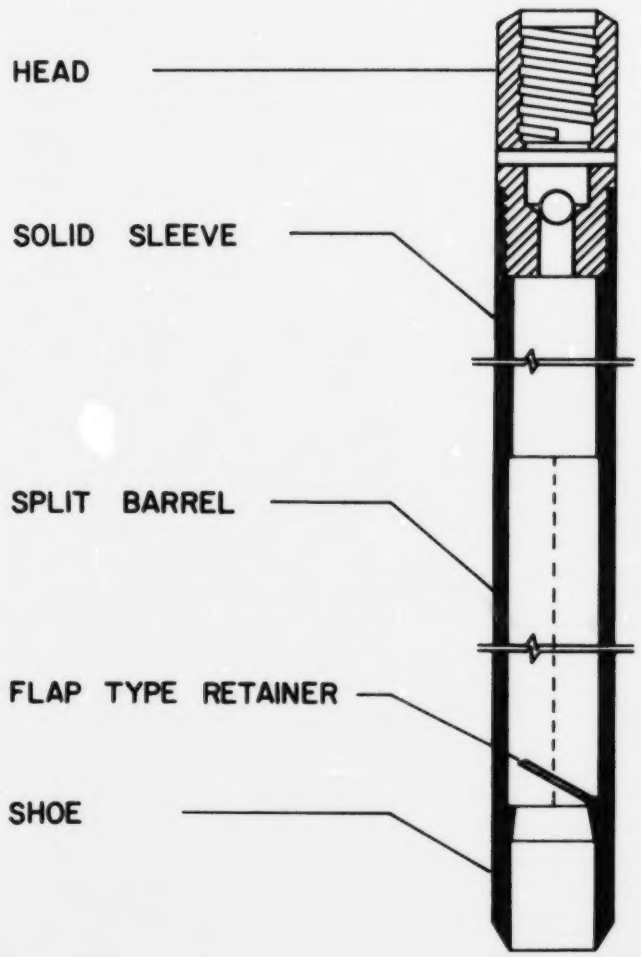
## 2.3 Split Spoon Sampler:

A split-spoon sampler is a drive sampler which is generally driven into the ground by a dropped, 63.5 kg weight falling freely onto an anvil attached to the top connecting rod. The samplers come in 45.7, 61.0 and 76.2 cm. lengths. The sampler consists of a barrel that can be split in half by the vise, a shoe which acts as a cutting edge and an adaptor to the A-rods with a slough barrel to hold excess material which has entered the borehole (Figure 7). The shoe can also have a spring loaded catcher near the cutting edge to prevent loss of sample when the sampler is retracted.

Advantages of the split-spoon sampler are that samples can generally be obtained from any material and it can be relatively easy to determine what part of the sample is really from the sampling location as the excess material in the borehole is pushed out of the sampler. Samples can be examined immediately upon being taken.

Disadvantages inherent with this sampling method are that at increasing depths continuous sampling can be very time consuming and therefore costly. Also, the use of the sample catcher although advantageous can have disadvantages as large material (i.e. pebbles, wood chips etc.) get wedged in the catcher during sampling resulting in little sample being recovered. Some fine-grained material may be lost out of the sampler resulting in a possible unrepresentative sample.

**Figure 7:** Split Spoon Sampler



## 2.4 Modified Shelby Tube Sampler:

A modified Shelby Tube was developed at the University of Waterloo and used at the Nordic tailings area by previous investigations (Cherry et al, 1980). The modified Shebly Tube consists of a thin-walled aluminum tube (0.127 cm) with a 7.6 cm I.D. and used in lengths up to 20 ft. . An adaptor head was fitted onto the top of the aluminum tube and coupled to A-rods up to the ground surface. Also coupled to the adaptor head is a 0.953 cm in I.D. tygon tube attached to a vacuum pump at ground surface. The entire assembly is lowered into the ground to the bottom of the borehole and vibrated to the desired sampling depth using a percussion rock drill attached to the A-rod at ground surface. Once the required sampling depth has been reached a vacuum is placed on the top of the sample to overcome the suction at the bottom of the sample.

The advantage of this method is that long continuous samples can be taken very quickly. The disadvantage is that the method is new and worked with varying degrees of success depending on the sample location the material sampled and the ability of the head assembly to retain a vacuum.

# 3.0 STUDY RESULTS:

The following section is a discussion of each of the sampling techniques used to obtain samples at the Nordic tailings and in the native materials below the Nordic tailings. The discussion pertains primarily to the factors that affected the decision to use a particular technique in a particular setting and results of using each technique.

## 3.1 Classical Shelby Tube Sampler:

Classical Shelby tube sampling was carried out primarily in the unsaturated zone above the water table and capillary zone. It was found in almost all cases, when the saturated tailings were sampled, that the samples were not retained in the sampler. In the coarse-grained tailings the lack of cohesion prevented the samples from

being retained and in fine-grained tailings cohesion was also lacking in most cases resulting in no retention of the sample. Before sampling was carried out at each site, the water table was measured, thus giving an indication of the depth to saturated tailings. The Shelby Tube sampler was then used until the sample was no longer retained. Below this depth alternative sampling techniques were employed.

During the initial phase of the project a variety of tests were carried out to determine which sample length and driving technique would give the optimum recovery under different tailings conditions (i.e. fine-grained, coarse-grained).

Shelby Tubes 5.1 cm in diameter and ranging in length from 45.7 cm to 152.4 cm were used in both fine-grained and coarse-grained tailings material. The 76.2 cm Shelby Tube appeared to yield the best results especially in the coarse-grained tailings regardless of the driving technique applied. In coarse-grained tailings, using 152.4 cm Shelby Tubes and driving the sample by pushing, hammering or turning, only a 50-60% recovery was achieved. Use of 76.2 cm Shelby Tubes resulted in an average recovery of 80-85% with a range of recovery from 60% to 90%. The low recovery is probably due to the compaction or compression of coarse-grained tailings with a low water content being pushed or packed tightly into the sampler. No sample was lost down the hole out of the sampler.

In some fine-grained tailings where a relatively high cohesion was found samples up to 152.4 cm could be obtained with 80-85% recovery. Sampling with a 76.2 cm Shelby Tube generally yielded greater than 95% recovery. With less cohesion, a lower percentage recovery was obtained especially in the larger Shelby Tubes, again probably due to compaction and compression and not sample loss. Since the cohesiveness of the tailings was not known the 76.2 cm Shelby Tubes were used for all unsaturated zone sampling.

## 3.2 Piston Sampler:

The piston sampler was found to have limited use over most of the tailings area. The piston sampler was designed for fine-grained materials. When tested on coarse-grained tailings, both above and below the water table, no sample was retained. The sample was generally lost upon extraction out of the borehole.

Although much of the tailings consists of fine-grained material, due to the nature of tailings deposition much of this material is relatively cohesionless. As such it acts in a similar manner to coarse-grained material when attempting to extrude a sample. Therefore, the only sampling a Piston sampler is suited for in tailings material is fine-textured with a relatively high cohesion. In areas where cohesive tailings were present almost complete recovery occurred with only a small loss of sample at the bottom of the sampler occurring occasionally.

The disadvantages of this method are that it generally is not known how cohesive the material will be prior to sampling and the sampling process appears to be the most time consuming.

## 3.3 Split-Spoon Sampling:

Split-spoon sampling was generally carried out to sample the native material below the tailings. This was done for two reasons. Firstly, other sampling methods were generally more efficient in the tailings, especially the modified Shelby Tube described in Section 3.4. Secondly, due to the compaction qualities of the peat, higher hydrostatic pressure with depth and the complete lack of cohesion in most of the sands and gravels below the peat layer, the split-spoon sampler, was the only sampling method that was able to recover any amount of uncontaminated sample.

Split-spoon samples were taken of the tailings - peat interface and tailings - sand interface where possible once the peat layer was located as described in the next section. Where the location of the interface was defined from previous work, a new borehole was drilled at the same location and continuous split-spoon samples were attempted from immediately above the expected interface. Sampling was carried out at varying depths into the underlying material depending on the type of material,

sample recovery, and importance of the sample. Difficulty was found with respect to sample recovery at depths of 3.0 - 4.6 m below the tailings in almost all cases.

Recovery at the tailings - peat and peat - sand interface was generally complete with recovery below this depth depending on the grain size. In areas where a fine to medium grained sand was found a recovery of 70-95% was generally obtained. The more coarse the material the lower the recovery and in many cases where gravel was found recovery was only 10-20%. Recovery was low because of sample loss in this case.

## 3.4 Modified Shelby Tube Sampler:

The Modified Shelby Tube sampling technique was the most commonly used technique in the tailings below the water table. Although the technique was new and relatively untried for most of the tailings area it appeared to work well in most cases for a number of reasons.

The most important factor in obtaining samples in the Nordic tailings was the general presence of the underlying peat layer which was often used as a plug in the bottom of the 6.1 m long Shelby Tube. A vacuum was applied in most cases and problems again occurred in cohesionless sand regardless of the suction applied. In these cases the entire sample generally was not lost and a 40-50% recovery could be obtained. Different sampler lengths were tried, ranging from 1.5 - 6.1 m, with similar results and it was decided to obtain whatever volume of sample possible in the coarse grained tailings until a depth of less than 6.1 m above the peat layer (if present) was reached.

A 6.1 m sampler was then hammered or pushed by hand in some cases until the peat layer was reached. The end of the sampler was then driven 10-20 cm into the peat depending on the hardness of the peat and this acted as a plug during sample retrieval. Full recovery was obtained for these samples and sampling was very time efficient. In some cases however, the sampler was driven too far into the peat and when the sample was extracted the poor clamp construction for attaching the aluminum tube to the adaptor resulted in the aluminum tube being pulled out from the adaptor and left in the borehole.

Because the sampler was used inside a 10.8 cm hollow stem auger, the augers were simply advanced into the peat layer and a plug was formed at the bottom of the auger. The augers were then removed from the borehole with the sampler intact, inside the augers.

The same procedures were applied to sampling in fine-grained tailings.

Reasonable recovery was obtained in many cases for samples taken above the peat layer by using the peat layer as a plug. Although most of the fine-grained tailings were relatively cohesionless, enough cohesive material was encountered within a 6.1 m length to retain most of the sample. The amount retained depended on the amount and location of these cohesive zones within the sample.

## 4.0 SAMPLE PREPARATION:

Samples obtained in the field were sealed either in Shelby Tubes or in air tight containers immediately upon extraction in order to prevent moisture loss. Sampling proceeded quickly in most cases and it was decided in conjuction with personnel from CANMET not to divide the larger samples into sub-samples until all samples had been collected. In this way decisions could be made, depending on the sample location and quality, as to the degree of sub-sampling necessary (i.e. 30.5, 15.2 or 2.5 cm sample lengths etc.). Appendix A describes the sample collection in the field. Descriptions of sub-samples taken were forwarded under seperate cover and are already being used by CANMET personnel to record various parameters for their own use and therefore will not be presented here.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS:

Continuous solids sampling of the Nordic uranium tailings was carried out at all ten sites on the Noridc Main tailings and six representative sites on the Nordic West Arm tailings to help facilitate better quantification of the radionuclide mass balance at the site and to aid in understanding the process of pore water evolution in the tailings.

Due to varying conditions such as depth to the water table, grain size distribution, soil cohesiveness, and underlying native material no one sampling technique could be used effectively. Different sampling techniques, for the variety of conditions, had to be improvised and developed in the field.

It was found that the classical Shelby Tube method worked best in the unsaturated material from the point of sample recovery and efficiency. A slightly better recovery was obtained in fine-grained tailings (95%) than in coarse-grained tailings (80-85%) using an optimum sampler length of 76.2 cm.

The piston sampler worked well in fine-grained soils with relatively high cohesion. However, it is difficult to determine the cohesiveness of the soil prior to sampling. This method was also very time consuming.

The standard split-spoon sampling method was used in the native materials below the tailings. Sample recovery depended almost entirely on grain size. (i.e. the greater the grain size, the poorer the recovery). This problem is typical of any material being sampled using a split-spoon and is not unique to this site.

The modified Shelby Tube appears to be better suited to sampling saturated tailings when compared to most standard techniques. However, the Nordic tailings is unique in having an underlying peat layer acting as a plug to enhance sample recovery. In fine-grained tailings sample recovery was generally good depending on the amount and location of relative cohesive layers of tailings within a 6.1 m sample zone. In coarse-grained tailings sample recovery was only fair (40-50%) as the lack of cohesion affects sample recovery in this technique just as it does in most other techniques.

Based on the results of this study a more detailed investigation should be carried out to examine new methods or adaptions of existing techniques to produce a sampler capable of sampling most or all tailings deposits as well as certain native materials in the vicinity of these deposits.

Two factors should be considered in developing a sampling technique. Firstly, and most importantly, it must be ensured that the sample recovered is uncontaminated and that the in-situ depth is known exactly. As a result the longer the sampler the better the overall result as the borehole disturbance and amount of sample taking is minimized. Secondly, and less important, the sample should be as undisturbed as possible in order to carefully examine the depositional features of tailings at the locations sampled. In this way a better understanding of the physical and chemical processes in tailings will be achieved.

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# APPENDIX A

## LIST OF SAMPLES TAKEN
## NORDIC TAILINGS

### KEY TO LIST

C.S.T. - CLASSICAL SHELBY TUBE
M.S.T. - MODIFIED SHELBY TUBE
S.S. - SPLIT-SPOON
P.S. - PISTON SAMPLER

| SITE | SAMPLING METHOD | LENGTH OF SAMPLE (cm) | DEPTH OF SAMPLE (m) |
|---|---|---|---|
| UW3 | C.S.T. | 58.4 | 0.0 -0.76 |
| | M.S.T. | 91.4 | 1.53-2.44 |
| | M.S.T. | 571.5 | 3.2 -8.92 |
| | S.S. | 50.8 | 9.0 -9.51 |
| | S.S. | 40.6 | 9.61-10.0 |
| | S.S. | 53.3 | 10.22-10.75 |
| UW6 | M.S.T. | 91.4 | 0.91-1.83 |
| | M.S.T. | 525.8 | 2.44-7.7 |
| | S.S. | 61.0 | 7.47-8.08 |
| | S.S. | 40.6 | 8.08-8.49 |
| | S.S. | 50.8 | 8.69-9.2 |
| UW5 | M.S.T. | 579.1 | 2.44-8.24 |
| | S.S. | 38.1 | 8.39-9.0 |
| UW8 | C.S.T. | 43.2 | 0.0 -0.76 |
| | M.S.T. | 533.4 | 3.0 -8.39 |
| | S.S. | 10.2 | 8.39-9.0 |
| | S.S. | 10.2 | 9.0 -9.6 |
| UW14 | C.S.T. | 61.0 | 0.0 -0.76 |
| | C.S.T. | 76.2 | 0.76-1.52 |
| | M.S.T. | 396.2 | 2.29-5.13 |
| UW16 | C.S.T. | 52.0 | 0.0 -0.76 |
| | M.S.T. | 533.4 | 1.52-6.86 |
| T1 | C.S.T. | 58.4 | 0.0 -1.52 |
| | P.S. | 76.2 | 1.52-2.9 |
| | P.S. | 137.2 | 2.9 -4.27 |
| | P.S. | 137.2 | 4.42-5.94 |
| | P.S. | 137.2 | 5.94-7.47 |
| | P.S. | 91.4 | 7.47-9.0 |
| | P.S. | 139.7 | 9.0 -10.52 |
| | P.S. | 30.5 | 10.52-10.82 |
| | S.S. | 45.7 | 10.36-10.97 |
| | S.S. | 40.6 | 10.97-11.58 |
| T2 | C.S.T. | 68.6 | 0.0 -0.76 |
| | C.S.T. | 63.5 | 0.76-1.52 |
| | C.S.T. | 55.9 | 1.52-2.29 |
| | C.S.T. | 64.8 | 2.29-3.05 |
| | C.S.T. | 61.0 | 3.05-3.81 |
| | C.S.T. | 71.1 | 3.81-4.57 |
| | C.S.T. | 22.9 | 4.57-5.33 |
| | S.S. | 50.8 | 5.33-5.94 |
| | M.S.T. | 442.0 | 5.94-10.36 |
| T3 | C.S.T. | 54.6 | 0.0 -0.76 |
| | C.S.T. | 45.7 | 0.76-1.52 |
| | C.S.T. | 35.6 | 1.52-2.29 |
| | C.S.T. | 55.8 | 2.29-3.05 |
| | C.S.T. | 55.8 | 3.05-3.81 |
| | C.S.T. | 68.6 | 3.81-4.57 |
| | C.S.T. | 68.6 | 4.57-5.33 |
| | C.S.T. | 33.0 | 5.33-6.1 |
| | M.S.T. | 198.1 | 6.1 -8.08 |
| | S.S. | 22.9 | 8.38-8.69 |
| | S.S. | 40.6 | 8.69-9.3 |
| | S.S. | 17.8 | 9.3 -9.91 |
| | S.S. | 20.3 | 9.91-10.52 |
| | S.S. | 5.1 | 10.52-11.13 |
| | S.S. | 5.1 | 11.13-11.73 |
| T4 | M.S.T. | 304.8 | 8.53-11.58 |
| | M.S.T. | 411.5 | 11.58-15.7 |
| T5 | M.S.T. | 213.4 | 4.27-6.53 |
| | M.S.T. | 165.6 | 6.71-8.38 |
| | M.S.T. | 182.9 | 11.58-13.41 |
| | M.S.T. | 213.4 | 14.78-16.92 |
| | S.S. | 31.8 | 16.61-17.22 |
| | S.S. | 10.2 | 17.22-17.83 |
| T6 | C.S.T. | 38.1 | 0.0 -0.76 |
| | C.S.T. | 67.3 | 0.76-1.53 |
| | C.S.T. | 73.7 | 1.52-2.29 |
| | C.S.T. | 64.8 | 2.29-3.05 |
| | C.S.T. | 55.9 | 3.05-3.81 |
| | M.S.T. | 91.4 | 3.81-4.72 |
| | M.S.T. | 594.4 | 6.86-12.8 |
| | S.S. | 73.7 | 12.95-13.72 |
| | S.S. | 45.7 | 13.72-14.33 |
| | S.S. | 33.0 | 14.48-15.09 |
| | S.S. | 17.8 | 15.09-15.70 |
| T7 | C.S.T. | 72.4 | 0.0 -0.76 |
| | C.S.T. | 58.4 | 0.76-1.52 |
| | C.S.T. | 48.3 | 1.52-2.29 |
| | C.S.T. | 57.2 | 2.29-3.05 |
| | C.S.T. | 63.5 | 3.05-3.81 |
| | C.S.T. | 58.4 | 3.81.4.57 |
| | C.S.T. | 55.9 | 4.57-5.33 |
| | C.S.T. | 55.9 | 5.33-6.1 |
| | C.S.T. | 73.7 | 6.1 -6.86 |
| | C.S.T. | 74.9 | 6.86-7.62 |
| | C.S.T. | 20.3 | 7.62-8.03 |
| | S.S. | 15.2 | 8.08-8.69 |
| | S.S. | 25.4 | 8.69-9.3 |

| SITE | SAMPLING METHOD | LENGTH OF SAMPLE (cm) | DEPTH OF SAMPLE (m) | SITE | SAMPLING METHOD | LENGTH OF SAMPLE (cm) | DEPTH OF SAMPLE (m) |
|---|---|---|---|---|---|---|---|
| T8 | C.S.T. | 7.62 | 0.0 -0.76 | T9 | C.S.T. | 48.3 | 0.0 -0.76 |
| | C.S.T. | 76.2 | 0.76-1.52 | | C.S.T. | 58.4 | 0.76-1.52 |
| | C.S.T. | 72.4 | 1.52-2.29 | | C.S.T. | 68.6 | 1.52-2.29 |
| | C.S.T. | 62.2 | 2.29-3.05 | | C.S.T. | 71.1 | 2.29-3.05 |
| | C.S.T. | 72.4 | 3.05-3.81 | | C.S.T. | 61.0 | 3.05-3.81 |
| | C.S.T. | 53.3 | 3.81-4.57 | | C.S.T. | 64.8 | 3.81-4.57 |
| | C.S.T. | 63.5 | 4.57-5.33 | | M.S.T. | 304.8 | 4.57-7.62 |
| | C.S.T. | 58.4 | 5.33-6.1 | | S.S. | 38.1 | 7.62-8.23 |
| | C.S.T. | 52.1 | 6.1 -6.86 | | S.S. | 30.5 | 8.23-8.66 |
| | C.S.T. | 72.4 | 6.86-7.62 | | S.S. | 17.8 | 8.84-9.45 |
| | C.S.T. | 27.9 | 7.62-8.03 | | S.S. | 20.3 | 9.45-10.06 |
| | M.S.T. | 335.3 | 8.38-11.73 | | S.S. | 7.6 | 10.06-10.67 |
| | M.S.T. | 30.5 | 12.19-12.50 | | | | |
| | S.S. | 15.2 | 12.50-12.80 | T10 | C.S.T. | 71.1 | 0.0 -0.76 |
| | S.S. | 27.9 | 12.80-13.4 | | C.S.T. | 73.7 | 0.76-1.52 |
| | | | | | C.S.T. | 73.7 | 2.29-3.05 |
| | | | | | C.S.T. | 76.2 | 3.05-3.81 |
| | | | | | C.S.T. | 76.2 | 3.81-4.57 |
| | | | | | C.S.T. | 102.9 | 4.57-6.1 |
| | | | | | C.S.T. | 52.1 | 6.1 -6.86 |
| | | | | | M.S.T. | 444.5 | 8.53-12.98 |